Options for measuring, preventing, and mitigating impacts due to improvements to the Sacramento and San Joaquin flood control projects

Our levee system is evolving to protect lives and property, but this evolution may cause external impacts

System design standard

- Design flows define intended capacity of Sacramento and San Joaquin systems; corresponding stages computed
- Developed by Corps from review of largest historical floods (1907, 1935-37, 1940, 1942, 1955)
- Freeboard added

Example of design profile

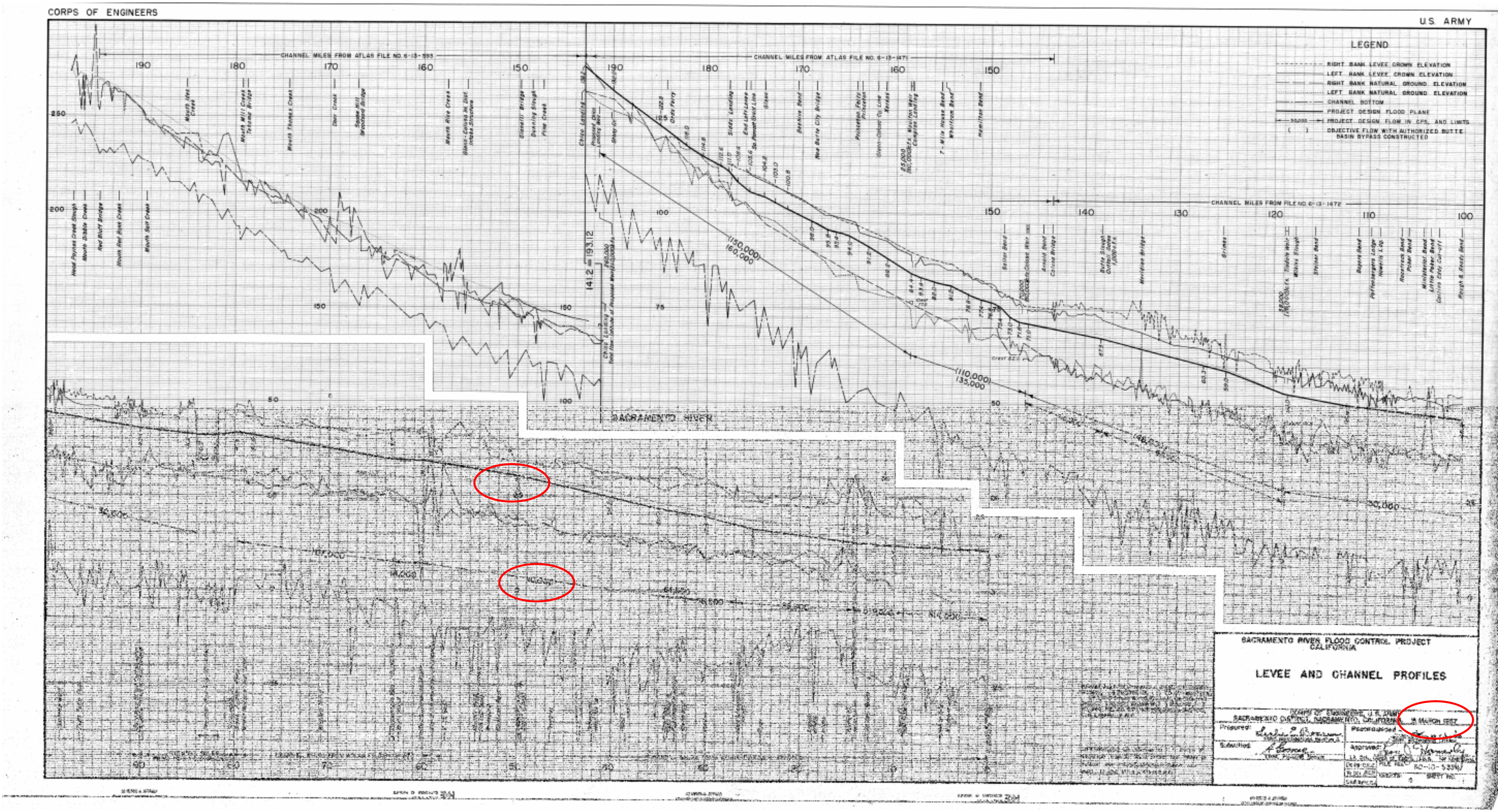


Figure 2 from report

Intended level of protection

River (1)	Location (2)	Design flow, cfs (3)	Return period, years (4)
Natomas Canal, Natomas Cross Canal, Pleasant Grove Creek Canal, East Side Canal	Back levees of RD 1000 and RD 1001	(varies by reach and within reaches)	200-year
Feather River	Left bank from Nicolaus to Bear River	320,000	25-year
Bear River	Left bank from Feather River to Western Pacific RR bridge	40,000	25-year
Feather River	Both banks from Marysville to mouth of Bear River	300,000	25-year
Bear River	Right bank from vicinity of Carlin Bridge to high ground	30,000	25-year
Feather River	Left bank from Yuba River to 1 mile downstream	30,000	25-year
Yuba River	Left bank from high ground at dredge tailings downstream to just beyond Southern Pacific RR bridge	120,000	20-year
San Joaquin	Merced River to Tuolumne River	45,000	50-year
San Joaquin	Tuolumne River to Stanislaus River	46,000	45-year
San Joaquin	Stanislaus River to Old River	52,000	45-year

Table 3 from report

Current estimates of protection

River (1)	Location (2)	Design flow, cfs (3)	Return period, years (4)
Sacramento	Butte City	160,000	50-year
Sacramento	Colusa	65,000	>100-year
Sacramento	Wilkensen Slough	30,000	10-year
Feather	above Yuba City	210,000	200-year
Feather	below Yuba River	300,000	125-year
Feather	Nicolaus	330,000	100-year
Sacramento	latitude Verona	450,000	50-year
Sacramento	latitude of Sacramento	590,000	100-year
Yuba	near Marysville	120,000	20-year
Bear		40,000	100-year
American	lower 5 miles	180,000	100-year
American	upstream	115,000	85-year
San Joaquin	near Maze Road bridge	46,000	50-year
San Joaquin	near Vernalis	52,000	90-year
Stanislaus	at Orange Blossom Bridge	12,000	200-year
Tuolumne	at Modesto	15,000	40-year

Table 4 from report; based on Comp. Study, from MBK

Levee raising

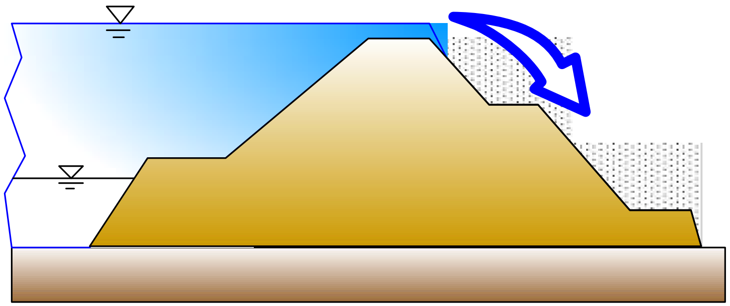


Figure 3 from report

- Direct, intended impact: Reduce overtopping
- Indirect impact: Alters channel geometry, so conditions upstream, downstream, or across stream change

Levee strengthening

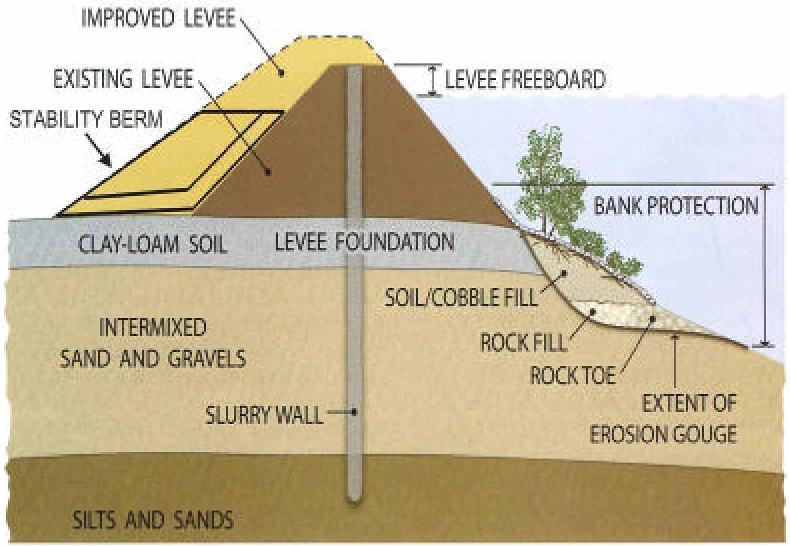


Figure 8 from report

- Direct, intended impact: Reduce probability of failure due to seepage, etc.
- Indirect impact: Increase flow rate, water level, probability of failure elsewhere

Levee relocation or realignment

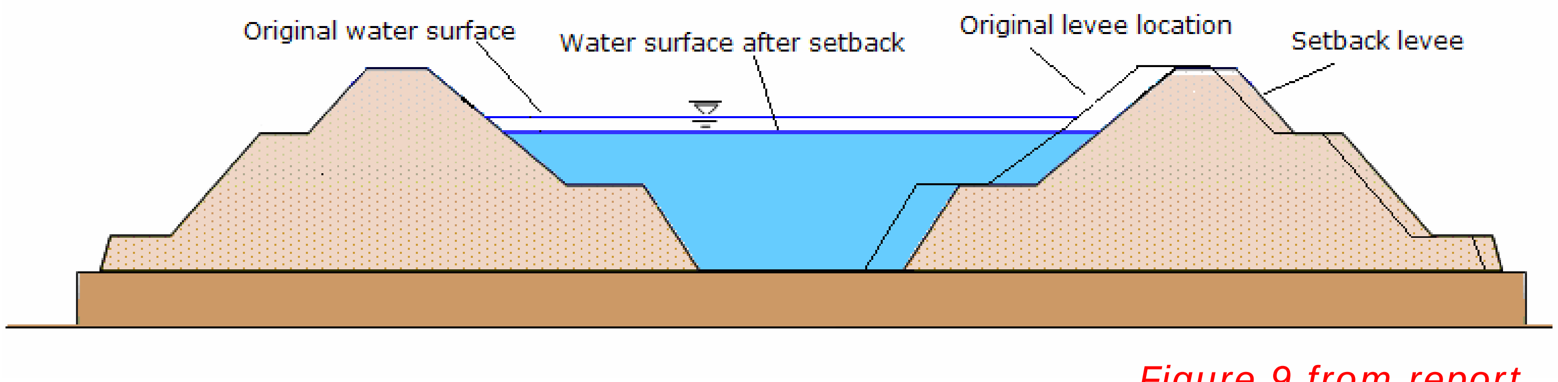


Figure 9 from report

- Direct, intended impact: Reduce water level
- Indirect impact: Change flow rate, water level elsewhere

We have options for measuring impacts

1. Change in water-surface elevation or flow conveyance for system design flow

- Measures impact as change in water level, compared to baseline level, considering design flow
- Requires definition of baseline for comparison
- Uses mathematical model of system hydraulics

Baseline condition

- State of system consistent with intended design
- Temporary conditions (such as erosion) not part of baseline
- Federally-authorized system improvements included

2. Change in water-surface elevation for flow of specified annual exceedence probability

- Measures impact as change in water level for event of selected probability (0.01, 0.005, or other).
- Requires baseline for comparison
- Needs frequency function
- Uses mathematical model of system hydraulics

Functions useful for impact evaluation

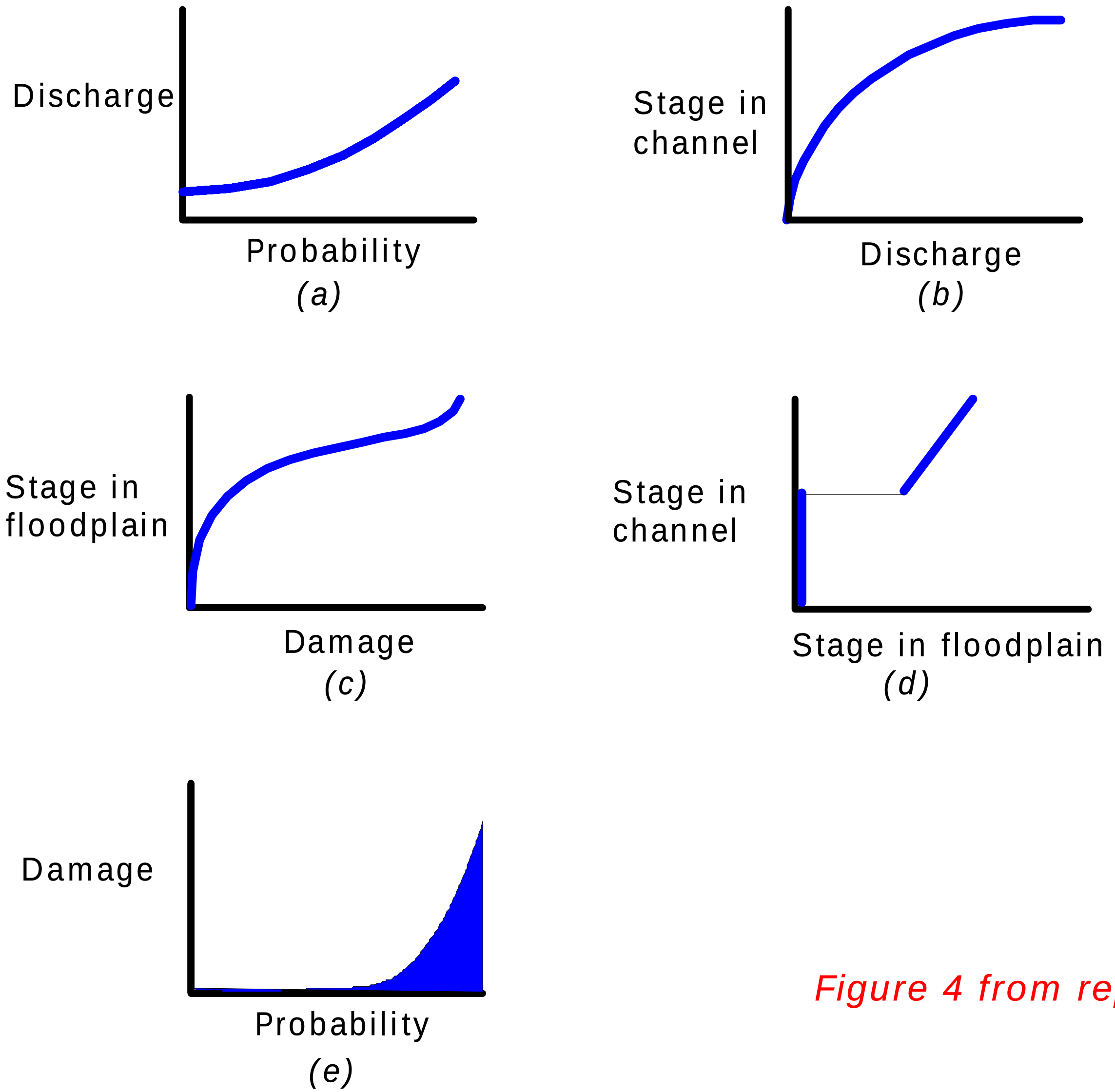


Figure 4 from report

3. Change in potential damage for system design flow

- Measures impact as change in potential damage due to design flow
- Requires baseline for comparison
- Uses mathematical model of system hydraulics + model of potential damage
- Can account for uncertainty of levee performance

Levee performance uncertainty

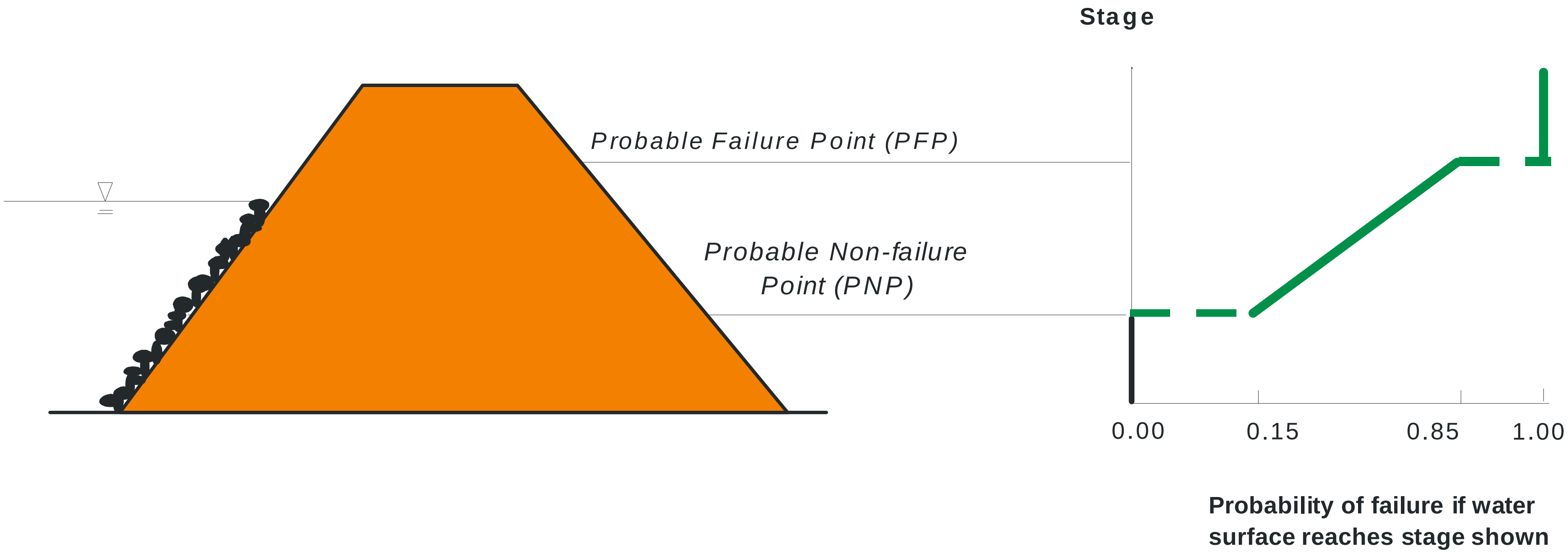


Figure 11 from report

4. Change in potential damage for flow of specified annual exceedence probability

- Measures impact as change in potential damage due to flow of selected probability
- Requires baseline for comparison
- Uses mathematical model of system hydraulics + model of potential damage
- Can account for uncertainty of levee performance

5. Change in expected annual damage (EAD)

- Measures impact as change in potential damage due to *all* flows, weighting each by likelihood
- Requires baseline, models, inventory
- Can account for uncertainty

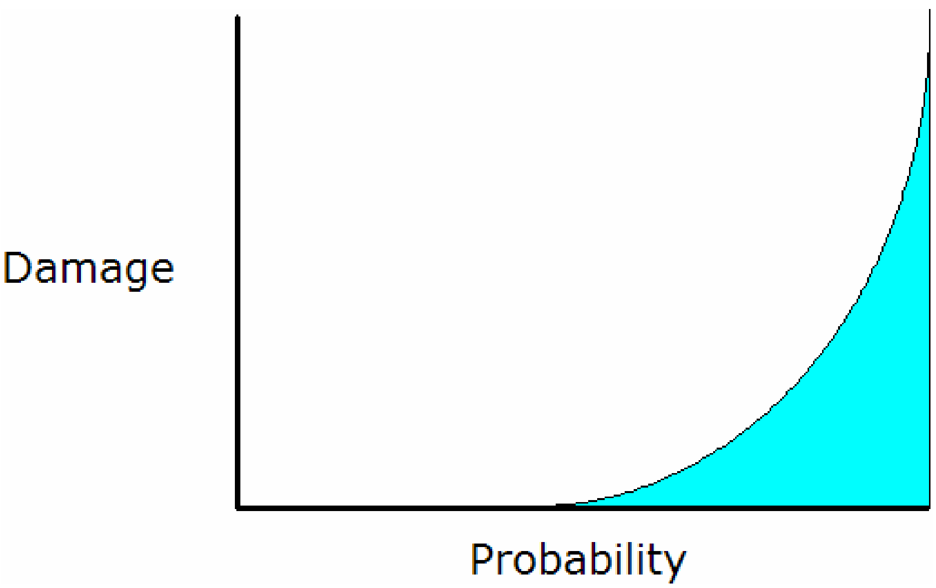


Figure 4e from report

6. Change in portion of expected annual damage due to flows greater than system design flow

- Similar to Index 5, but considers only potential damage due to events that exceed design flow

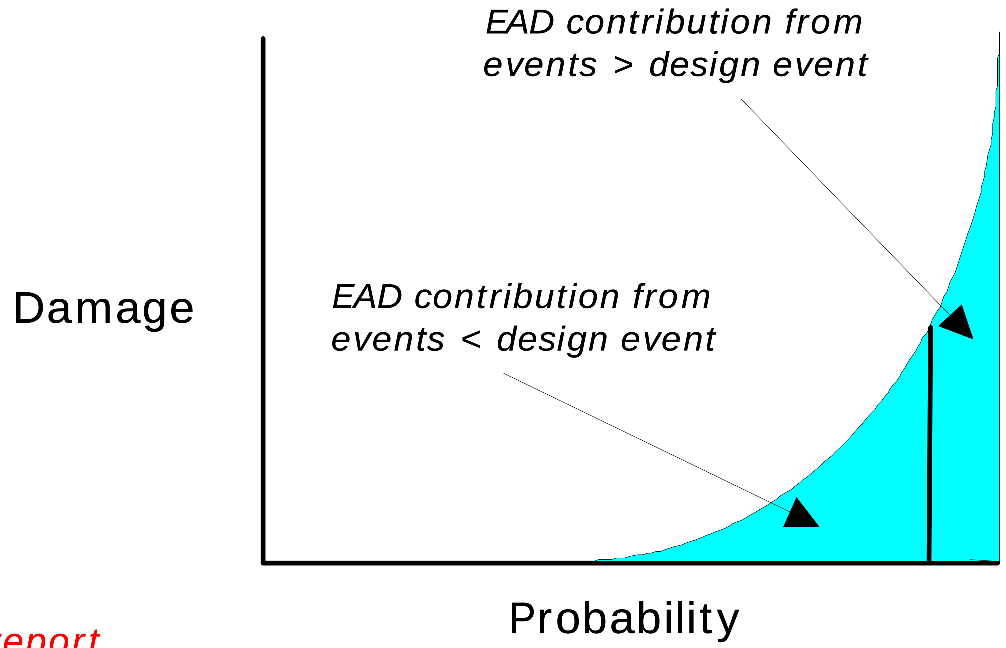
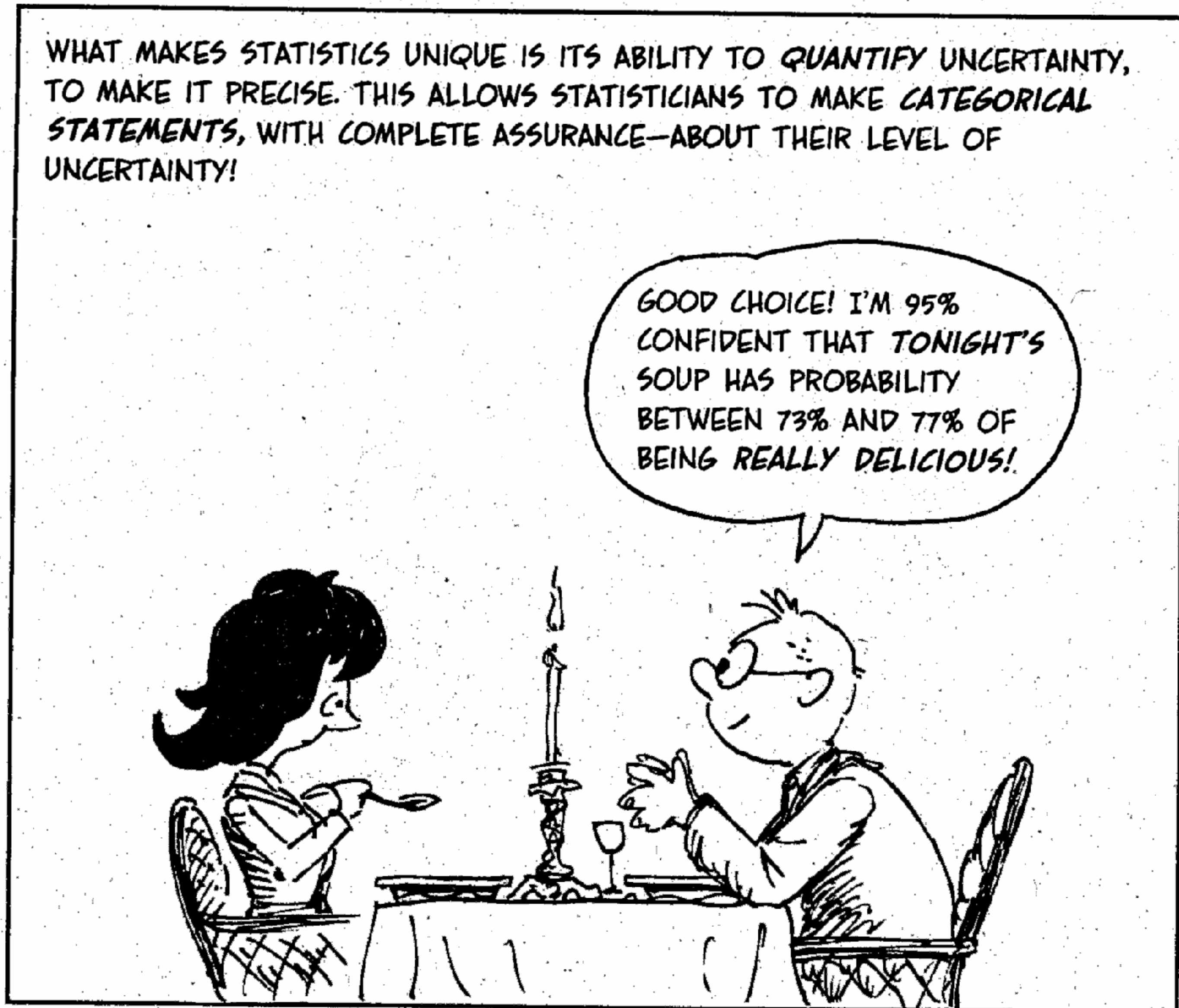


Figure 10 from report

7. Change in annual probability of inundation of interior floodplain

- Measures impact as change in likelihood of any flooding, without reference to consequences
- Consistent with traditional *level of protection;* also know as AEP
- Uses model of system hydraulics
- Can account for uncertainty of levee performance



From The cartoon guide to statistics *by Gonick and Smith, 1993*

8. Change in probability of passing safely design flow

- Levee performance and knowledge of hydrology and hydraulics uncertain
- Index measures impact as change in likelihood of performing as designed, given models of uncertainty
- Uses model of system hydraulics

9. Change in probability of passing safely flow of specified probability

- Measures impact as change in likelihood of passing flow of selected probability
- When applied to p=0.01 (100 yr) event, consistent with Corps' *level of assurance* standard for levee certification
- Uses model of system hydraulics, models of uncertainty

Practical considerations

- Hydraulic modeling software
- Risk evaluation software
- Data requirements
- Expertise required
- Consideration of system-wide impacts
- Computational tolerances

We have options for preventing or mitigating impacts

1. Avoid the impact by disallowing the improvement

- Just **don't** do it
- Ensures no adverse impact
- Could stall or stop improved protection, development, intensification

2. Mitigate adverse impact with construction of structural measure(s)

- Uses structural fix to mitigate
- Permits continued improvement
- May create yet another impact
- Cost may be great

3. Notify those who may suffer adverse impacts

- Already required and accomplished; provides opportunity to act
- Allows continued improvement
- Does nothing to reduce increase flow, stage, risk

4. Reimburse those who suffer increased damage potential (single event or expected)

- Reimbursement may be (a) EAD increase; (b) increment for selected event
- Payment could be annual or lump sum
- Makes whole those damaged
- Doesn’t stop the damage

5. Insure those with increased damage potential

- Insure to reimburse those damaged, if and when they are
- Allows continued improvements
- Does not eliminate impact
- Considers only direct, tangible cost

6. Collect impact fee to offset increased construction cost for system-wide plan of flood control

- Acknowledges goal of plan of flood control
- If local improvements increase cost of plan elsewhere, fee offsets increase
- Allows continued improvement
- Collecting fee does not eliminate impact

7. Pay the cost associated with any increased damage if and when it occurs

- Similar to Option 4, but pays when damage incurred
- Allows continued improvement
- Does not eliminate adverse impact

8. Provide other types of insurance

- Purchase or lease flowage easements to ensure additional offsetting storage
- Allows continued improvement
- May be difficult to implement and administer